

# Assessment of Remediation Technologies for Cleanup of Oiled Shorelines, Tide Flats, and Salt Marshes within the Kingdom of Saudi Arabia

## Project Characteristics:

- *Assessment of Environmental Damage to Beaches, Tide Flats, & Marshes from the 1991 Gulf Oil Spill*
- *Laboratory Assessment of Aerobic & Anaerobic Oil Remediation Methodologies*
- *Germination & Survivability Tests of Native Marsh Species in Contaminated Soils*
- *Field Scale Demonstration of Marsh Restoration*
- *Field Scale Demonstration of Oil Remediation Techniques*
- *Environmental Impact Assessment*
- *Development of Full Scale Remediation Strategy*

Woods Hole Group, Inc., under contract to the Environmental Consulting Bureau of the Kingdom of Saudi Arabia (KSA), conducted a field demonstration of oil remediation techniques applicable to arid environments. Approximately 750 km of shoreline within the Kingdom of Saudi Arabia along the Arabian Gulf were impacted as a direct result of the 1991 Gulf War.

The area covered in this field study extends along the KSA Arabian Gulf shore from the Kuwait border to the industrial city of Al-Jubail. This complex shoreline is composed of an interlaced series of tide flats, beaches, embayments, and salt marshes. Much of these ecosystems remain severely impacted from the oil spill.

The Remediation Technology Assessment (RTA) was designed to follow a logical, sequential series of steps representing international protocol for conducting remediation technology evaluations that relied heavily on approaches developed by the United States Environmental Protection Agency (U.S. EPA). Utilizing this approach assured that the designed approach was credible, complete, replicable, and reliable.



The major steps in the RTA conduct included:

- Literature survey of remediation technologies
- Design and review of laboratory-scale remediation trials
- Conduct of laboratory-scale remediation trials
- Design and review of field-scale remediation trials
- Conduct of a baseline environmental study of the field-scale trial demonstration sites
- Conduct of field-scale remediation trials
- Post-demonstration environmental impact assessment of field-scale trial sites
- Final review and assessment of field and laboratory trials
- Interaction between RTA and Ecological Risk Assessment to determine environmental risks associated with various remediation technology options.
- Recommendations to the Client of considerations for implementing full scale remediation

This sequential design was followed in a general sense, but the accelerated schedule associated with the UNCC damage claims process required constant amendments to the scheduling of these various tasks. Lack of availability of some equipment locally also affected the ability of the field trials to be carried out as designed; modification to the field trial operations plan was required nearly daily to respond to lessons learned during the previous work. However, all tasks were completed successfully on schedule.

## Remediation (continued)

The laboratory-scale trials provided important conclusions for the field-scale trials. Laboratory studies included:

- Assessment of anaerobic biodegradation in petroleum-contaminated sediments
- Assessment of aerobic biodegradation in petroleum-contaminated sediments
- Assessment of germination of *Salicornia* in petroleum contaminated sediments
- Assessment of thermal treatment for petroleum contaminated sediments

The field-scale trials provided important conclusions for the full-scale remediation of the coastal zone. Field trials spanned a series of materials handling trials, as well as clean-up trials. Remediation trials included:

- Tilling and perforations
- Excavation
- Rock removal
- Rock breaking and fracturing
- Removal of tar mats
- Berming
- Restoring tidal channels
- Restoring microtopography
- Planting for revegetation trials

Extensive work on materials handling was conducted, both in the field and in consolidated materials handling yard. Requirements for transportation, for separation, for handling were all tested in the field. Recommendations for effective use of each of these techniques were developed and are presented to the Client.

Unit costs for all work also were developed based on the field trials. Although large-scale remediation will present certain economies of scale, the mixture of high technology (HTTD) and low technologies required the development of a complex costing matrix to estimate and control costs.



The technology trade-offs and costs were presented such to the Client could modify a specific plan for remediation based on the eventual award from the UNCC.

The Environmental Baseline Study and the Environmental Impact Assessment developed certain conclusions and recommendations on the effectiveness of the remediation techniques evaluated. Combined with the ecological risk assessment, the EIA concluded that remediation reduces the ecological risk to the environment, in the majority of habitats and environments, in spite of short-term adverse impacts resulting from remediation construction. Specific guidelines for how to minimize adverse environmental impacts during remediation of various environments and associated habitats are presented in tabular form. These tables provide guidance to the process of restoration.